Electronic Version
Stylesheet Version v1.1.1

Claims

[c1] 1. A method for nondestructive testing with flaw simulation, comprising the steps for:

storing a geometry of a test piece and a positional map of virtual flaw signals for the test piece in a control computer;

causing a nondestructive testing probe to scan a test piece by movement of the probe over the test piece by an inspector;

tracking nondestructive testing probe positions with respect to the test piece and sending probe position signals to the control computer;

processing nondestructive testing probe output signals and displaying the processed signals to the inspector;

injecting virtual flaw signals into the processed probe output signals based on the probe positions, the stored test piece geometry and the stored positional map for determining virtual flaw response signals; and

displaying the virtual flaw response signals to the inspector.

[c2] 2. The method of claim 1, wherein the steps for processing probe output signals and injecting virtual flaw signals comprise the steps for:

sending excitation signals to the probe from conventional nondestructive test instrumentation through a virtual flaw signal injection circuit;

receiving the probe output signals by a virtual flaw signal injection circuit;

computing virtual flaw signals by the control computer based on the probe positions, the stored geometry of the test piece and the stored positional map of virtual flaw signals for the test piece;

combining the probe output signals and the virtual flaw signals from the control computer by the virtual flaw signal injection circuit for determining the virtual flaw response signals; and

sending the virtual flaw response signals from the virtual flaw signal injection circuit to the conventional nondestructive test instrumentation for displaying the virtual flaw response signals to the inspector by the conventional nondestructive test instrumentation.

[c3] 3. The method of claim 2, further comprising sensing nondestructive testing probe liftoff from the test piece, sending probe liftoff signals to the control computer, and using the probe liftoff signals for computing virtual

flaw signals.

[c4] 4. The method of claim 3, wherein the steps for processing probe output signals and injecting virtual flaw signals comprise the steps for:

sending excitation signals to the probe and receiving the probe output signals by conventional nondestructive test instrumentation;

receiving output signals from the conventional nondestructive test instrumentation by the control computer;

computing virtual flaw signals by the control computer based on the probe positions, the probe liftoff signals, the stored geometry of the test piece and the stored positional map of virtual flaw signals for the test piece;

combining the conventional nondestructive test instrumentation output signals and the virtual flaw signals by the control computer for determining virtual flaw response signals; and

sending the virtual flaw response signals from the control computer to a computer monitor for displaying the virtual flaw response signals to the inspector.

[c5] 5. The method of claim 1, wherein the step for storing in a control computer comprises the steps for:

reading and storing virtual flaw signals data;

reading and storing the test piece geometry;

generating one or more positional maps of virtual flaw signals for the test piece; and

reading liftoff correction parameters.

[c6] 6. The method of claim 3, wherein the step for computing virtual flaw signals by the control computer comprises the steps for:

reading and storing the probe position signals;

reading and storing the liftoff signals;

reading and storing the positional map of virtual flaws;

calculating virtual flaw signals using the probe position signals and the positional map;

applying liftoff correction to the calculated virtual flaw signals; and

sending the corrected virtual flaw signals to the virtual flaw signal injection circuit.

[c7] 7. The method of claim 4, wherein the step for computing virtual flaw signals by the control computer comprises the steps for:

reading and storing the output signals from the conventional nondestructive test instrumentation;

reading and storing the probe position signals;

reading and storing the liftoff signals;

reading and storing the positional map of virtual

flaws;

calculating virtual flaw signals using the probe position signals and the positional map;

applying liftoff correction to the calculated virtual flaw signals; and

combining the corrected virtual flaw signals with the signals from the conventional nondestructive test instrumentation and sending the combined signals to the computer monitor.

[c8] 8. The method of claim 1, wherein the nondestructive testing probe is selected from the group consisting of an eddy current probe and an ultrasonic probe.

[c9] 9. The method of claim 3, wherein a liftoff sensor is selected from the group consisting of an eddy current sensor, a capacitive sensor and an optical sensor.

[c10] 10. The method of claim 1, wherein the nondestructive testing probe is selected from the group consisting of a single element probe for receiving excitation signals and transmitting test signals, a dual element probe for receiving excitation signals on one element and transmitting test signals from a second element, and a triple element probe for receiving excitation signals on one element and transmitting test signals differentially from the other two elements.

[c11] 11. The method of claim 1, wherein the step for displaying the virtual flaw response signals comprises the step for displaying the virtual flaw response signals and actual flaw response signals to the inspector.

[c12] 12. The method of claim 3, further comprising the step for displaying virtual flaws to an inspector on a computer monitor connected to the control computer for instructional training purposes.

[c13] 13. The method of claim 1, further comprising the step for deriving the positional map of virtual flaws from a model of conventional nondestructive test instrumentation responses.

[c14] 14. The method of claim 1, further comprising the step for deriving the positional map of virtual flaws from actual premeasured flaw signals from conventional nondestructive test instrumentation.

[c15] 15. A computer-readable medium containing instructions for controlling a computer system to implement the method of claim 1.

[c16] 16. A computer-readable medium containing instructions for controlling a computer system to implement the method of claim 6.

[c17] 17. A computer-readable medium containing instructions for controlling a computer system to implement the method of claim 7.

[c18] 18. A system for nondestructive testing with flaw simulation, comprising:

means for storing a geometry of a test piece and a positional map of virtual flaw signals for the test piece in a control computer;

means for causing a nondestructive testing probe to scan a test piece by movement of the probe over the test piece by an inspector;

means for tracking nondestructive testing probe positions with respect to the test piece and sending probe position signals to the control computer;

means for processing nondestructive testing probe output signals and displaying the processed signals to the inspector;

means for injecting virtual flaw signals into the processed probe output signals based on the probe positions, the stored test piece geometry and the stored positional map for determining virtual flaw response signals; and

means for displaying the virtual flaw response signals to the inspector.

[c19] 19. The system of claim 18, wherein the means for processing probe output signals and injecting virtual flaw signals comprises:

means for sending excitation signals to the probe from conventional nondestructive test instrumentation through a virtual flaw signal injection circuit;

means for receiving the probe output signals by a virtual flaw signal injection circuit;

means for computing virtual flaw signals by the control computer based on the probe positions, the stored geometry of the test piece and the stored positional map of virtual flaw signals for the test piece;

means for combining the probe output signals and the virtual flaw signals from the control computer by the virtual flaw signal injection circuit for determining the virtual flaw response signals; and

means for sending the virtual flaw response signals from the virtual flaw signal injection circuit to the conventional nondestructive test instrumentation for displaying the virtual flaw response signals to the inspector by the conventional nondestructive test instrumentation.

[c20] 20. The system of claim 19, further comprising means for sensing nondestructive testing probe liftoff from the test piece, sending probe liftoff signals to the control

computer, and using the probe liftoff signals for computing virtual flaw signals.

[c21] 21. The system of claim 20, wherein the means for processing probe output signals and injecting virtual flaw signals comprises:

means for sending excitation signals to the probe and receiving the probe output signals by conventional nondestructive test instrumentation;

means for receiving output signals from the conventional nondestructive test instrumentation by the control computer;

means for computing virtual flaw signals by the control computer based on the probe positions, the probe liftoff signals, the stored geometry of the test piece and the stored positional map of virtual flaw signals for the test piece;

means for combining the conventional nondestructive test instrumentation output signals and the virtual flaw signals by the control computer for determining virtual flaw response signals; and

means for sending the virtual flaw response signals from the control computer to a computer monitor for displaying the virtual flaw response signals to the inspector.

[c22] 22. The system of claim 18, wherein the means for displaying the virtual flaw response signals comprises displaying the virtual flaw response signals and an actual flaw response signals to the inspector.

[c23] 23. The system of claim 20, further comprising displaying virtual flaws to an inspector on a computer monitor connected to the control computer for instructional training purposes.

[c24] 24. A system for nondestructive testing with flaw simulation, comprising:

conventional nondestructive testing instrumentation including a probe connected to a simulation means;

means for tracking positions of the probe with respect to a test piece and providing a probe position tracking signal to the simulation means;

means for sensing liftoff of the probe from the test piece and providing a probe liftoff signal to the simulation means; and

the simulation means comprising a computer including:

means for monitoring the probe position tracking signal;

means for monitoring the probe liftoff signal;

means for storing virtual flaw signals that are a function of probe position;

means for providing virtual flaw signals as a function of the probe position tracking signal and the probe liftoff signal for combining with nondestructive testing instrumentation probe signals; and

means for combining a signal from the conventional nondestructive testing instrumentation with a simulated virtual flaw signal from the simulation means; and

means for displaying the combined signals to an inspector.

[c25] 25. The system of claim 24, wherein:

the combining means is a virtual flaw signal injection circuit for receiving virtual flaw signals and output signals from the probe, the virtual flaw injection circuit providing a combined signal to the conventional nondestructive testing instrumentation; and

the displaying means is the conventional nondestructive testing instrumentation for displaying actual and virtual flaws.

[c26] 26 The system of claim 24, further comprising a display means connected to the simulation means for displaying simulated virtual flaw signals for instructional training purposes.

[c27] 27. The system of claim 24, wherein:

the combining means is the simulation means for receiving an output signal from the conventional nondestructive testing instrumentation to be combined with the simulated virtual flaw signal; and
the displaying means is a computer monitor connected to the simulation means for displaying actual and virtual flaws.

[c28] 28. The system of claim 24, wherein the conventional nondestructive testing instrumentation is based on eddy current nondestructive testing methods.

[c29] 29. The system of claim 24, wherein the conventional nondestructive testing instrumentation is based on ultrasonic nondestructive testing methods.

[c30] 30. The system of claim 24, wherein the virtual flaw signals are created from pre-measured signals from actual defects.

[c31] 31. The system of claim 24, wherein the virtual flaw signals are created from a mathematical model.